New Home for "Old Fourlegs"

How the Coelacanth was Discovered on the Other Side of the Indian Ocean

Text & Photographs by MARK V. ERDMANN

"CEPAT BOSS! ADA RAJA Laut!" (*Come quickly! The King of the Sea!*). The words shouted from the shore by my boatman sent pulses of excitement through me. I nearly flew over the steps to the beach from my house on the Indonesian island of Sulawesi, my wife, Arnaz, close on my heels with video camera in hand. In the shallows, surrounded by three beaming fishermen, lay the unmistakable brown-and-white dappled form of an adult coelacanth, gently sculling its curious lobed fins. Our ten-month search, fraught with frustration and anticipation, had been rewarded.

The long and colorful story of the coelacanth has been called "a biological thriller," complete with chance discoveries, eccentric characters, dogged investigation, and international intrigue. At the heart of all of this human folly is an ancient group of fishes. Coelacanths arose in the fossil record almost 400 million years ago and until 1938 were only known to a few paleontologists as a long-extinct lineage of fishes. Prominent among the strange morphological features that distinguished these fishes were their lobed fins, thought by some to be the precursors of legs on modern land animals. Though this group diversified to include at least 80 species, ranging in size from eight inches to over twelve feet in length, they appeared to have disappeared almost 70 million years ago.

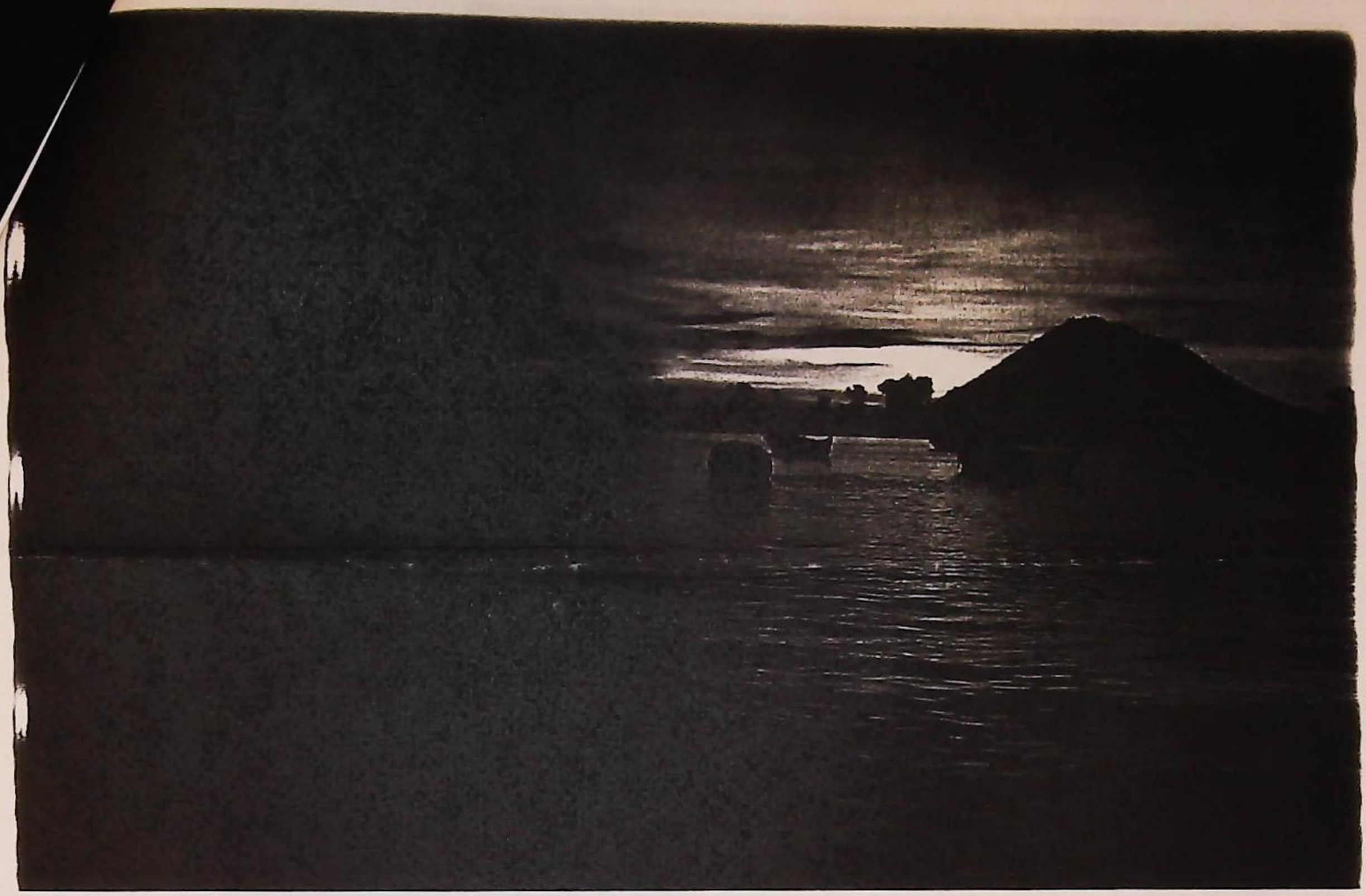
Little wonder, then, that the fantastic discovery of a living coelacanth, trawled off the coast of South Africa in 1938, was heralded as "the greatest zoological find of the century." Newspaper articles were rife with clichés about this "living fossil" that many speculated was the "missing link" between finned fishes and four-legged amphibians. The famous South African ichthyologist J.L.B. Smith took on the task of describing this fish, which he christened *Latimeria chalumnae* in honor of the enthusiastic young museum curator, Marjorie Courtenay Latimer, who had recognized the fish as something special and saved it from a heap of trawled sharks.

Unfortunately, the important soft parts of the specimen were lost to the summer heat, so Smith became obsessed with finding a second specimen to finish his anatomical investigations into this evolutionary enigma. His search took 14 long years of combing the east African coastline with his wife and his assistant, Margaret, speaking with fishermen and distributing reward posters.

Their efforts finally paid off in late 1952, when the "true home" of the coelacanths was discovered in the remote Comores archipelago, northwest of Madagascar. Although Smith managed to get his second specimen back to South Africa with the help of his prime minister and a military plane, French authorities were understandably a bit miffed at having this headline-grabbing fish "stolen" from their colony. They closed the Comores to international researchers for the next two decades. Smith dramatically related his fantastic fish odyssey in a classic book, *Old Fourlegs*.

Additional specimens continued to be captured in the Comores, where the coelacanth was an occasional bycatch for fishermen who targetted the medicinally valuable oilfish using handlines baited with

In 1997, a chance encounter at Manado's fish market with this specimen set the author on a ten-month search for a second fish to confirm that a population of coelacanths existed more than 6,000 miles from their only known home.



Sunset behind Manado Tua, on the northern tip of Sulawesi, Indonesia. Fishermen who set gill nets along the island's submerged volcanic slopes sometimes catch coelacanths, known as the "King of the Sea," instead of the intended sharks or snappers.

fish or chicken and sunk to depths of 500 feet or more. Long considered worthless to the Comorans due to its oily, inedible flesh, the coelacanth was transformed into a highly prized trophy as international researchers offered rewards for its capture. A number of coelacanth-hunting expeditions arrived in the Comores, but none were successful. The California Academy of Sciences launched just such an expedition in 1975, but in the end the team members (including Sylvia Earle, John McCosker, Al Giddings, and Michael Lagios) settled for purchasing two frozen specimens (see "To the Islands of the Moon," *Pacific Discovery*, January-February 1976). By the late 1980s, at least 200 specimens had been captured and sold to museums and collectors the world over.

Though such intensive collecting was less than favorable for coelacanth population size, it did allow a monumental research effort into the species' anatomy and physiology. *L. chalumnae* reaches a maximum length of over six feet and can weigh over 220 pounds. They give birth to live young; one captured female was carrying 26 fetuses, each 14 inches long. Besides their lobed fins, coelacanths are unique in having an "extra" epicaudal lobe on the tail and an intracranial joint in the skull that may permit a wider mouth gape for catching prey. Like many sharks and rays, coelacanths are thought to locate their prey with an electroreceptive organ in their snout.

Coelacanth blood is also similar to that of sharks, although their hemoglobin structure seems to closely align coelacanths to the tetrapods (four-legged land animals). But coelacanth chromosomes most closely resemble those of an ancient frog species. Because of these contrasting data, *L. chalumnae*'s evolutionary kinship remains an enigma, and researchers still hotly debate their position on the tetrapod family tree.

Despite this wealth of information gleaned from captured specimens, details of the deep-dwelling coelacanth's natural history were virtually unknown. This changed dramatically in 1987, when Hans Fricke and his team from the Max Planck Institute in Germany led a submersible expedition to the Comores and succeeded in finding the fish in its native habitat. Results of this and five subsequent submersible expeditions have revealed many fascinating details of the coelacanth's ecology. Typically inhabiting steep, young volcanic slopes at depths of 500 to over 2,500 feet, *L. chalumnae* is a slow-moving, nocturnal drift hunter that targets small to medium-sized bottom fishes and cephalopods. The species appears to require cooler water temperatures (optimally less than 65 °F). During daylight hours the coelacanth shelters in lava caves in non-aggressive groups of up to 14 animals per cave. It has a unique locomotion: alternately sculling its fins in a manner that resembles a horse at slow trot.

Perhaps the most telling discovery of Fricke's team is the apparent, drastic

decline in the coelacanth population on Grand Comore Island. They reported a 30 percent decrease in estimated population size between 1991 and 1994 (to less than 1,000 animals), prompting alarm. It seems likely that even greater reductions occurred previously during the heavy demand for specimens. Declines of such magnitude could be disastrous, as *L. chalumnae* is believed to exist only in the Comores. The four known specimens caught elsewhere (South Africa, Mozambique, and Madagascar) are all considered to be "strays" from the main Comoran population, based on genetic comparisons and the apparently unsuitable habitat at these locations.

With such a limited geographic range, *L. chalumnae* has been given the dubious honor of being one of the few marine fishes listed on the International Union for the Conservation of Nature Red List of Endangered Species and as a CITES Appendix 1 species that is restricted from international trade. Some coelacanth experts, however, make the point that too little is known about the natural population size and distribution to conclude that coelacanths are endangered.

AGAINST THIS DIRE PROGNOSIS, our announcement of coelacanths in Indonesia certainly came as welcome news for their conservation. The two specimens that we observed from the volcanic island of Manado Tua in North Sulawesi could hardly be strays from the Comoran archipelago—over 6,000 miles away and downstream of the prevailing currents from Indonesia.

Like Marjorie Latimer's 1938 discovery, ours was purely a matter of chance. Shortly after our wedding in Bali in September 1997, Arnaz and I were in North Sulawesi on a house-hunting trip before I began my postdoctoral research project to develop a coral reef biomonitoring program for Indonesia. Our friends John and Janel Intihar had accompanied us, and we decided to show them Manado's open-air fish market. As we stepped out of the taxi at the market, Arnaz's attention was immediately drawn to a large, strange-looking fish being wheeled across the parking lot.

HANS FRICKE/ JÜRGEN SCHAUER

It became impossible to forget the fish. I was fully infected with "coelacanth fever."

While I recognized the fish as a coelacanth, and knew from schoolboy readings that the coelacanth was only known from the Comores, I found it hard to believe that we could have stepped out of a taxi in a bustling city and made such a major discovery. Surely coelacanths must have been previously described from Indonesia.

Still hesitant about whether we should try to buy the fish (and wondering where we would fit a large, dead fish in our boutique hotel room), I took several photos with Janel's camera while Arnaz asked the fisherman about his catch. In broken Indonesian he explained that the fish had been caught the previous evening in deep water off Manado Tua, and that he had seen this same species occasionally in the past. As he uncomfortably began to retreat from all this attention, we reasoned that if this did turn out to be a major discovery, we could always find another fish during my two-year project in Manado.

Several days later, on a plane trip to the United States for a brief visit home, I felt lingering remorse. Had I just made the biggest mistake of my life by not buying that fish? At the University of California in Berkeley, I rushed into the office of my postdoctoral advisor, Roy Caldwell, who quickly confirmed that this was indeed a fish story of grand proportions. We discussed plans to find another specimen, and I attempted to keep the coelacanth out of my thoughts until we returned to Indonesia the next month.

But it became impossible to forget the fish. Unbeknownst to me, John and Janel had posted to an Internet website pictures from our wedding and honeymoon, including the coelacanth photos from the market! Amazingly, news of these photos quickly circulated among fish scientists, and I was contacted by David Noakes (a former Berkeley Ph.D. student) about the find. He urged me to remove the photos,

Left: Fabled as living fossils and biological enigmas, much about coelacanths remains a mystery. Submersible dives by a German expedition to the Comore Islands in the Indian Ocean filmed coelacanths swimming at night and clustering by day inside lava caves, such as this group is doing off Grand Comore.

Below: Gold flecks on the scales appear to distinguish Indonesian coelacanths from those found in the Comore Islands. Bigger differences lie beneath the surface: Genetic comparisons of this specimen to Comoran coelacanths suggest that the Indonesian population belongs to a distinct species that split off at least 5.5 million years ago.

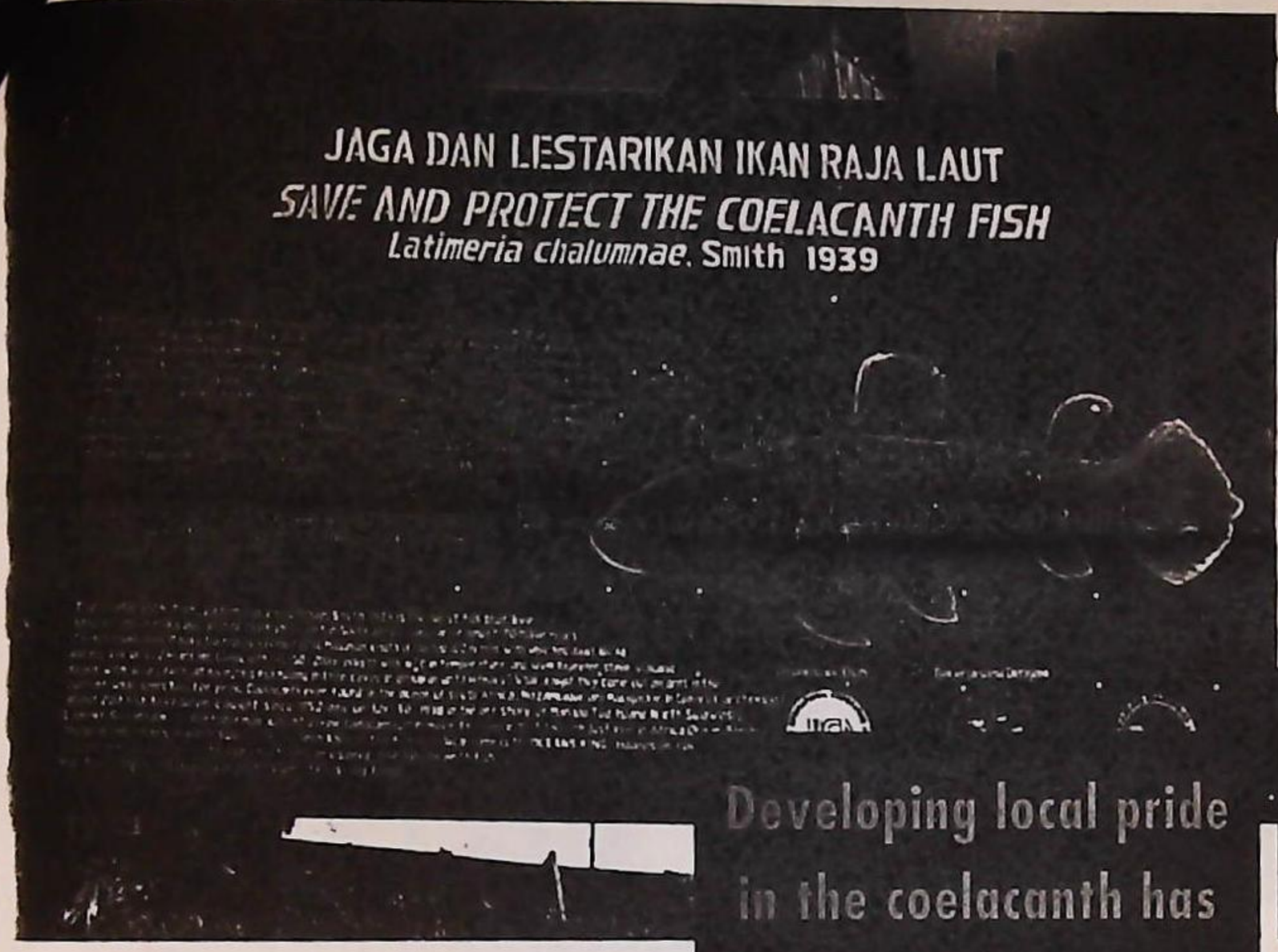
lest they prompt a "gold rush" of exotic animal collectors to Manado. The photos were pulled from the website within hours, but by then I was fully infected with the "coelacanth fever" that seems to befall any researcher who gets involved with these strange beasts. My postdoctoral research project was about to take a dramatic and irreversible deep dive into the realm of the coelacanths.

Arnaz and I returned to Indonesia two weeks later, determined to find a second specimen. Funded by the National Science Foundation and the National Geographic Society, we began interviewing fishermen throughout North Sulawesi using our photographs of the original market fish. As the initial expectant weeks of the search turned into months, the blank looks of many fishermen humbly reminded me of Smith's protracted search for a second fish. Would history repeat itself?

Fortunately, by March 1998 we had identified two groups of fishermen who claimed to know the coelacanth well. One group insisted that the fish we sought was the *ikan sede*, while the second group countered that this fish was unmistakably the *Raja Laut*, or "King of the Sea." Our dilemma was solved later that month when an *ikan sede* was brought to us, and it turned out to be the oilfish, the species targeted by Comoran fishermen when they accidentally catch coelacanths. So we focused on the *Raja Laut* fishermen, who target sharks and deep-water snappers by using deep-set gill nets that extend to over 1,000 feet in depth. Our efforts paid off on July 30, 1998, when Om Lameh Sonatham of Manado Tua brought the second known Indonesian coelacanth to the beach in front of my house. Fate had kindly foreshortened Smith's 14 years to a much more bearable ten months.

Given the precarious status of the coelacanth in the Comores, our first priority after verifying its existence in Indonesian waters was to ensure that measures be put in place to protect this population. We delayed publication of our find until I was able to inform the relevant Indonesian scientists and government officials of this important discovery and the immediate need for conservation. Though the Indonesian government is hardly known for its bureaucratic efficiency, I was astounded by the speedy and enthusiastic response. A major publicity campaign ensued, led by the Indonesian Institute of Sciences (LIPI). Coelacanth information brochures and posters were distributed widely, and press releases were televised nationwide. Our efforts eventually culminated in a national law proclaiming the

Near each location where a coelacanth has been caught off the coast of Sulawesi, a sign alerts residents and visitors to the fish's presence and importance.



Developing local pride in the coelacanth has already had positive conservation effects.

Above: Craftswomen in Manado have begun to embroider coelacanths on handkerchiefs and shirts and include the fish in designs for necklaces and napkin rings to sell in local dive shops.

coelacanth a precious natural heritage to be strictly protected from capture or trade.

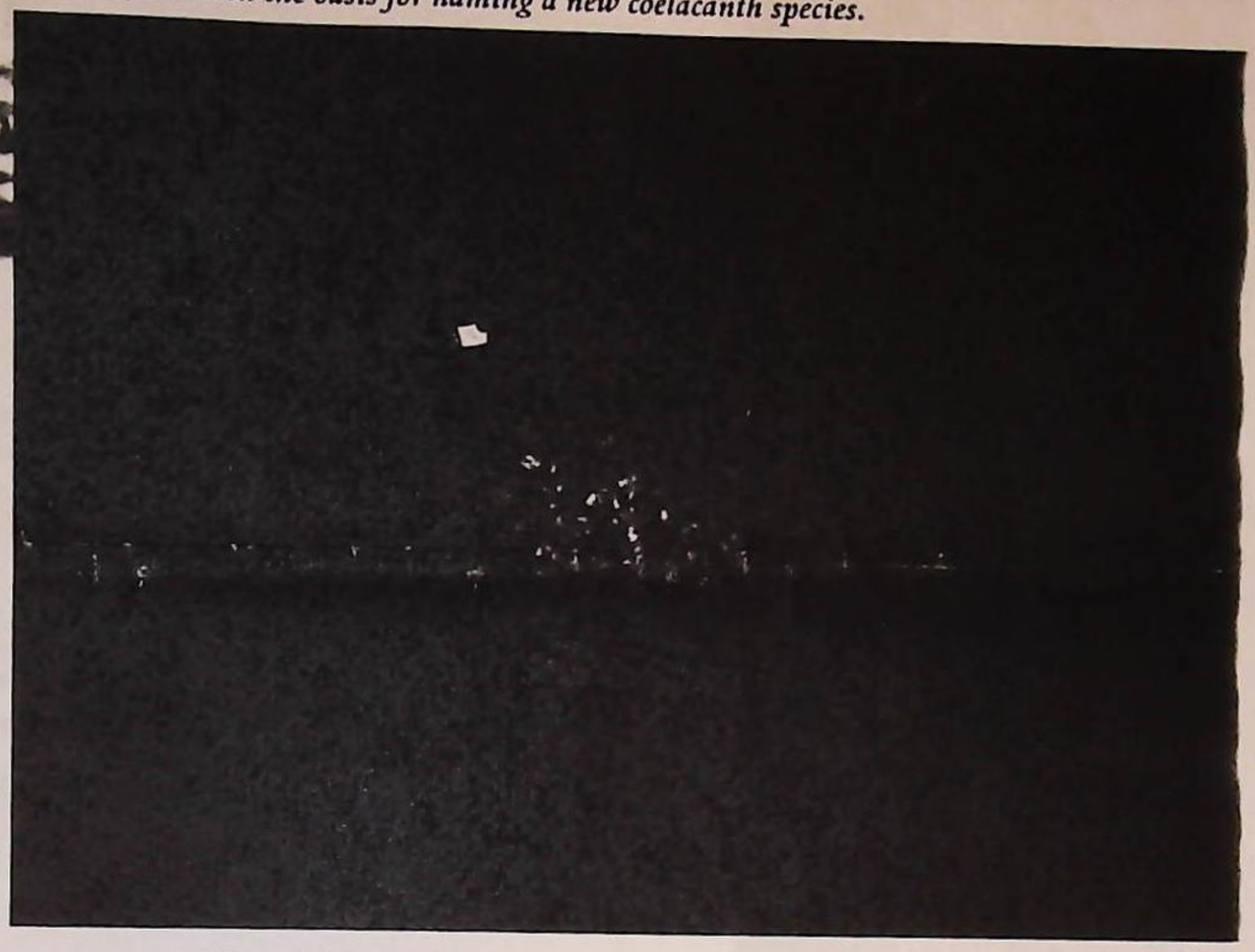
With conservation measures well underway, in September 1998 Roy Caldwell, LIPI scientist M. Kasim Moosa, and I published a brief announcement of the find in the journal *Nature* and were subsequently overwhelmed by the storm of ensuing publicity. Clearly, our next priority was to determine if the Indonesian specimen was indeed *L. chalumnae*, or if it represented a distinct species. Other than the obvious geographic distance from the Comoran population, one clue was the apparent color difference of the Indonesian fish. While *L. chalumnae* is commonly described as metallic blue with white spots, our specimen was brown and white, with striking gold flecks on the scales.

An initial examination of the specimen's external anatomy revealed a remarkable similarity to published accounts of *L. chalumnae*, and we turned instead to a genetic comparison. Those results, published last October in the *Proceedings of the National Academy of Sciences*, indicated an average of 4.1 percent divergence between mitochondrial DNA sequences from the Indonesian fish and a Comoran specimen. Our best "molecular clock" estimate suggested that these two populations had been separated for at least 5.5 million years, and possibly as long as 11 million years. The weight of evidence led us to conclude that the Indonesian fish represented a new species, so I contacted several ichthyologists to locate a qualified collaborator to help describe the new species with my Indonesian colleagues.

True to its history of intrigue, the coelacanth tale here takes an ugly turn. While awaiting word of acceptance of the article describing our genetic results, I was flabbergasted to learn of the description of a new species of coelacanth, *Latimeria menadoensis*, by the French aquaculturist Laurent Pouyaud and five Indonesian co-authors. Though the full story will perhaps never be known, it became obvious that Pouyaud resorted to shady maneuverings in order to obtain tissue from the specimen that I had donated to LIPI. Though he obtained this tissue under the pretense of a simple genetic analysis, he expanded the results of that analysis into a cursory description of the new species and hastily published it in a sympathetic French journal, *Comptes Rendus de L'Academie des Sciences*. The paper immediately caused a minor furor in the academic world, as the incomplete description ignored much of the protocol of modern taxonomy (failing to designate, for instance, a holotype specimen for the new species) and presented several mistaken morphological and genetic differences with *L. chalumnae*.

Sloppiness aside, however, the paper was also highly questionable ethically. Pouyaud's Indonesian "coauthors" were unaware of the description until it was published, and were understandably upset at having their own work on the taxonomic description of this new species subsumed while they were relegated to junior authorship of "Pouyaud et al." Nevertheless, the species name *menadoensis* seems to be here to stay. Just another chapter in the ongoing coelacanth saga.

The author's wife, Arnaz, swims beside an Indonesian coelacanth caught by fishermen in July 1998. This specimen, which the author donated to the Indonesian Institute of Sciences, has been the basis for naming a new coelacanth species.



FORTUNATELY, THE SULAWESI chapter has had some highlights as well, particularly regarding conservation. The coelacanth has filled the much-needed role of "flagship species" for marine conservation in North Sulawesi, and the publicity surrounding the fish has focused attention on the urgent need for better management of Indonesia's marine parks (particularly the Bunaken National Park where the coelacanths have been caught). LIPI has continued to push a major conservation agenda, and with support from the Japan International Cooperation Agency, has distributed coelacanth hats, T-shirts, posters, and an excellent children's book in which a lost baby coelacanth eloquently argues for proper management of Indonesia's marine resources. A drawing contest on "The Coelacanth and his Seas" received 1,185 entries from over 40 schools in North Sulawesi.

Moreover, the coelacanth is beginning to provide local economic benefits. With the help of a rotating credit scheme that we have instituted, entrepreneurial villagers are now producing an array of coelacanth handicrafts—embroidered handkerchiefs and shirts, and carved coconut shell hair clips, necklaces, and napkin rings—for sale to tourists.

Developing local pride in the coelacanth has already had positive conservation effects. Under the watchful eyes of two local policemen who have adopted the coelacanth's well-being as their personal obligation, fishermen have now rejected four separate attempts by foreign aquarium representatives to capture coelacanths for live display. Additionally, a World Wide Fund for Nature (WWF) grant is now supporting an education and monitoring program for local youth volunteers in the Bunaken marine park. This program will both provide further education for fishers and their children about the coelacanth, and maintain daily monitoring for coelacanth catches and attempted purchases within the park. These local conservationists may soon have international law on their side, too; Indonesia, Germany, and France have put forth official proposals to expand CITES Appendix I protection to include the Indonesian coelacanth by the middle of the year.

The logical next step is to determine the population size and geographic range of *L. menadoensis* and to develop appropriate management policy. In November 1999, a collaborative expedition between LIPI and Hans Fricke's *JAGO* submersible team attempted this study, which ended in a manner most appropriate to the coelacanth drama. After 32 unsuccessful submersible dives throughout North Sulawesi, most of our team wearily disembarked in Manado before the mother ship headed back to Jakarta at the end of the expedition. During the voyage home, remaining team members Jürgen Schauer and Karen Hissmann had enough time to make one final submersible dive on the northern arm of Sulawesi. To their surprise, they found two coelacanths together in a deep carbonate cave! The researchers filmed the pair briefly before strong currents swept the craft away from the cave. Questions about the natural history of *L. menadoensis* will remain unanswered until another expedition can be launched later this year. One thing is certain: The saga of the "King of the Sea" is far from over, and it is sure to contain further mysteries and intrigue.

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Cover: Although common in Southeast Asia, the green tree viper is venomous but not enough to warrant its highly dangerous reputation. On page 30, Academy herpetologist Joe Slowinski reveals the world's deadliest snake and describes the variety of potent venoms that snakes possess. Photograph by Dong Lin.